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(71) Applicant: EVEREADY BATTERY COMPANY, INC.  
[US/US]; P.O. Box 450777, 25225 Detroit Road, Westlake,  
OH 44145 (US).(72) Inventors: KELEMEN, Marc, P.; 31230 Hilliard Boulevard,  
Westlake, OH 44145 (US). SVEC, Susan, L.; 6873 Stearns  
Road, Olmsted Township, OH 44138 (US).(74) Agent: TOYE, Russell, H., Jr.; Eveready Battery Company,  
Inc., 25225 Detroit Road, P.O. Box 45077, Westlake, OH  
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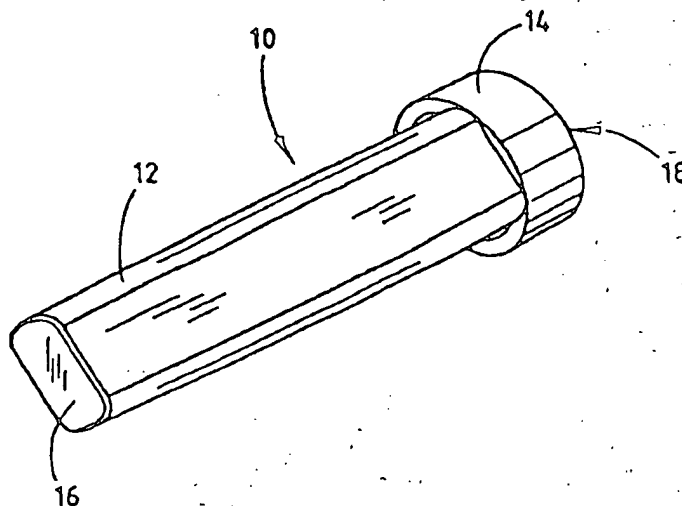
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(54) Title: ELECTROCHEMICAL CELL FORMED WITH BIG MOUTH OPEN END CAN

## (57) Abstract

A cell with considerably less wasted space may be prepared by starting with a non-cylindrical can (10) where the open end has an over-sized mouth (18) which, after at least partial filling of the can, can be crimped and, ultimately, sealed.



ELECTROCHEMICAL CELL FORMED WITH  
BIG MOUTH OPEN END CAN

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The present invention generally relates to electrochemical cells and, more particularly, to a method of assembling an electrochemical cell having a non-cylindrical container.

10

Conventional alkaline cells commonly employ a cylindrical shaped steel can provided with a positive cover at one end and a negative cover at the opposite end. The cylindrical steel can houses a positive electrode, referred to as the cathode, which is preferably formed of a mixture of manganese dioxide, graphite, potassium hydroxide solution, deionised water, and other additives, and is commonly formed about the interior

15 side surface of the cylindrical steel can. A cup-shaped separator is commonly disposed about the interior surface of the cathode. A negative electrode, referred to as the anode, which is typically formed of zinc powder, a gelling agent, and other additives, is dispensed within the separator along with electrolyte solution.

20

Conventional cylindrical cells are widely available in sizes AAAA, AAA (R03), AA (R6), C (R14), and D (R20) for use as the power source for various electrically operated devices. Despite the popularity of the conventional cylindrical cells, it has been discovered that there is a potential need to provide for non-cylindrical cell configurations. One such

25 potential need exists for use in a multiple-cell battery, such as the 9-volt battery, which commonly houses six 1.5 volt cells electrically connected in series. In the past, multiple cylindrical cells have been assembled together in a rectangular container, thereby resulting in unused space between adjacent cells as well as between each cell and the inside walls of the battery container. In addition, it has also been discovered that many battery operated electrical devices are capable of using non-cylindrical cells which may allow for increased

30 service performance. An example of a non-cylindrical cell is disclosed in co-pending U.S. application Serial No. 09/110119, entitled "Electrochemical Cell and Battery" filed on April 2, 1998, to Lewis Urry.

A primary goal in designing alkaline batteries is to increase the service performance of the cell. Another goal is to achieve high quality cell assembly techniques. The service performance is the length of time for the cell to discharge under a given load to a specific voltage at which the cell is no longer useful for its intended purpose. Commercially available alkaline cells and batteries have an external size that is commonly defined by industry standards, thereby limiting the ability to increase the amount of active materials within a given cell and to confine the volume that is available. Accordingly, the need to find new ways to increase service performance and provide suitable assembly techniques remains a primary goal of the cell designer.

It has now been found that it is possible to provide a cell with considerably less wasted space by starting with a non-cylindrical can where the open end has an over-sized mouth which, after at least partial filling of the can, can be crimped and, ultimately, sealed.

The present invention improves the assembly of a cell having a non-cylindrical prismatic can, such as a rectangularly configured can, by providing the can with an enlarged open end to accommodate assembly of active materials into the cell, and reducing the enlarged open end to a reduced size round open end that may advantageously be fit with a compact round cover.

Accordingly, in a first aspect, the present invention provides a technique, or method, of assembling an electrochemical cell, comprising using an open-ended, non-cylindrical can, preferably having a substantially fixed cross-section along its length, the mouth of the open end being generally circular, the mouth having no dimension smaller than any dimension of the radial cross-section of the can, and wherein the mouth of the can is reduced in size during or after the loading of the other elements, before being sealed. In such a way, there is no impedance of loading of the constituents of the cell, and the end cover may, conveniently, be circular.

In general, it is preferred that the mouth be coaxial with the remainder of the body of the can. This provides for ease of manufacture, and minimal wasted material in the construction of the mouth of the can.

1 The body of the can may be of any general shape, such as square, rectangular, or  
2 oval, or may have an irregular shape, but it is generally preferred that the cross-section is  
3 consistent along the length of the cell, for filling purposes. The mouth of the can will then  
4 have no dimension smaller than the largest cross-sectional dimension of the can, and is  
5 preferably substantially circular.

6 The transition from the open end of the can to the mouth is not crucial to the  
7 invention. The transition may be abrupt, or gradated. However, a gradated transition is  
8 generally preferred, in order to minimise wastage of material, both from the point of view of  
9 construction, and the amount of material that needs to be compressed or crimped to reduce  
10 the mouth size.

11 The mouth need not necessarily be circular after reduction, but other shapes often  
12 tend to be more difficult to produce, reliably, leading to problems with assembling covers  
13 onto them. Thus, a substantially circular reduced mouth is preferred.  
14

15 It will be appreciated that, while the starting size of the mouth is generally bigger  
16 than the can, the final size is preferably as small as, or smaller than, the overall radial area of  
17 the can, preferably with no dimensions exceeding any of those of the radial cross-section of  
18 the can.  
19

20 In general, the cell may be constructed by means known in the art, and such as are  
described below.

21 Generally, the present invention provides a method of assembling an electrochemical  
22 cell comprising the steps of providing a can having a prismatic section with a closed bottom  
23 end and a big mouth round open top end. The big mouth round open top end has a diameter  
24 that is at least as wide as the maximum inside cross-sectional width of the prismatic section.  
25 The method includes the step of disposing a cathode into the prismatic section through the  
26 big mouth open top end. The cathode is configured with a cavity formed therein and is  
27 disposed in the can such that the cathode consumes a substantial volume of the prismatic  
28 section between the cavity and inner walls of the can.. The method further includes the steps  
29 of disposing a separator within the cavity and further disposing an anode within the separator  
30

in the cavity. According to the method, the size of the big mouth open top end is reduced in size to provide a reduced diameter open top end upon which a round cover is assembled.

In another aspect, the present invention provides a method of assembling an  
5 electrochemical cell comprising the steps of:

providing a can having a prismatic section with a closed bottom end and a big mouth  
open top end that is substantially round with a diameter equal to or greater than the  
maximum inside cross-sectional width of the prismatic section;

10 disposing a cathode through the big mouth open top end and into the prismatic  
section, the cathode having a cavity centrally formed therein and disposed so that the cathode  
consumes a substantial volume of the prismatic section between the cavity and inner walls of  
the can;

disposing a separator within the cavity;

disposing an anode within the separator in the cavity;

15 reducing the size of the big mouth open top end of the can to provide a reduced size  
round open top end; and

assembling a cover to the reduced size round open top end.

More generally, there is provided a method of assembling an electrochemical cell  
20 comprising the steps of:

providing a can having a non-cylindrical section with a closed bottom end and a big  
mouth open top end that is substantially round with a diameter equal to or greater than the  
maximum inside cross-sectional width of the non-cylindrical section;

25 disposing a first electrode through the big mouth open top end and into the non-  
cylindrical section, the first electrode having a cavity centrally formed therein and disposed  
so that the first electrode consumes a substantial volume of the non-cylindrical section  
between the cavity and inner walls of the can;

disposing a separator within the cavity;

disposing a second electrode within the separator in the cavity;

30 reducing the size of the big mouth open top end of the can to provide a reduced size  
round open top end; and

assembling a cover to the reduced size round open top end.

In a preferred embodiment, there is provided a ring moulding method of assembling an electrochemical cell comprising the steps of:

providing a can having a prismatic section with a closed bottom end and a big mouth open top end that is substantially round with a diameter equal to or greater than the maximum inside cross-sectional width of the prismatic section;

forming one or more moulded cathode rings, each of the cathode rings configured to fit inside the prismatic section of the can and further having a cavity formed therein;

disposing the one or more cathode rings through the big mouth open top end and into the prismatic section such that the one or more cathode rings consumes a substantial volume of the prismatic section between the cavity and inner walls of the can;

disposing a separator within the cavity;

disposing an anode within the separator in the cavity;

reducing the size of the big mouth open top end of the can to provide a reduced size round open top end; and

assembling a cover to the reduced size round open top end.

In an alternative embodiment, there is provided a method of assembling an electrochemical cell comprising the steps of:

providing a can having a prismatic section with a closed bottom end in a big mouth open top end that is substantially round with a diameter equal to or greater than the maximum inside cross-sectional width of the prismatic section;

disposing a cathode into the prismatic section;

disposing an anode into the prismatic section;

disposing a separator between the anode and cathode;

reducing the size of the big mouth open top end of the can to provide a reduced size round open top end; and

assembling a cover to the reduced size round open top end.

It is preferred to form the can to include a cylindrical section that provides the big mouth open top end. It is also preferred to form a tapered transition between the prismatic section and the cylindrical section.

In general, it is preferred to reduce the big mouth open top end such that the diameter of the reduced open top end is less than or equal to the minimum cross-sectional width of the prismatic section. A preferred technique for doing this is rotary swaging.

5 In a preferred embodiment, the prismatic section has a substantially rectangular section.

It is preferred that the step of disposing the cathode into the can comprises a cathode ring moulding process, especially where the cathode ring moulding process includes the step  
10 of inserting multiple cathode rings stacked one on top of another.

In general, it is preferred to dispense a current collector in contact with the anode. The can is preferably a steel can.

15 The non-cylindrical section is preferably a prismatic section.

It is preferred that the anode and cathode are disposed within the prismatic section such that the prismatic section is substantially consumed by the anode and cathode.

20 The step of disposing the cathode into the prismatic section preferably includes forming a cavity centrally therein and disposing the cathode such that the cathode consumes a substantial volume of the prismatic section between the cavity and inner walls of the can, wherein the anode and separator are disposed within the cavity.

25 The present invention also provides an electrochemical cell comprising:  
a container having a prismatic section with a closed bottom end and a round open top end, the container initially having a big mouth open top end with a diameter greater than or equal to the maximum inside cross-sectional width of the prismatic section;  
a first electrode disposed substantially within the prismatic section;  
30 a second electrode disposed substantially within the prismatic section;  
a separator disposed between the first and second electrodes; and  
a round cover, wherein the big mouth open top end of the can is reduced in size to a reduced size round open end subsequent to the insertion of the first electrode so that the

reduced round open end has a diameter that is less than or equal to the minimum cross-sectional width of the prismatic section, and the cover is assembled to the reduced round open end of the can. Generally preferred features of such a cell are as detailed above, with respect to the method of the invention.

5

The big mouth open top end of the can advantageously allows for assembly of the cathode, particularly for ring moulding assembly, and reduction of the big mouth open top end subsequent to insertion of the cathode allows for a reduced size round top cover to be assembled thereto.

10

The present invention will be further illustrated with reference to the accompanying drawings, in which:

Figure 1 is a perspective view of a prismatic steel can having a cylindrical section with a big mouth open end for use in the cell assembly of the present invention;

15 Figure 2 is a top end view of the prismatic can of Figure 1;

Figure 3 is a perspective view of a prismatic steel can with the big mouth open end and further including a tapered transition according to another embodiment;

Figure 4 is a flow diagram illustrating the method of assembly of an electrochemical cell according to the present invention;

20 Figure 5 is an exploded view of a partially assembled cell illustrating ring moulded cathode assembly;

Figure 6 is a perspective view of a partially assembled cell illustrating the prismatic can having a reduced size round open end according to the assembly method of the present invention;

25 Figure 7 is a top end view of the partially assembled cell of Figure 6 further illustrating the reduced size round open end of the can;

Figure 8 is a cross-sectional view of the fully assembled cell taken through its longitudinal axis; and

30 Figure 9 is a radial cross-sectional view of the fully assembled cell taken through lines IX-IX of Figure 8.

Referring to Figures 1 and 2, a prismatic steel can 10 is shown having an enlarged open end, which is referred to herein as the big mouth open end 18, for use in the assembly



of an electrochemical cell according to the present invention. Steel can 10 includes a non-cylindrical prismatic section 12, shown configured as a rectangular section, having a closed bottom end 16. Opposite the bottom end 16, steel can 10 has a cylindrical section 14 that transitions from the prismatic section 12 to the big mouth open top end 18. The prismatic section 12 of cell 10 is provided with four substantially planar and rectangularly-shaped side walls that may be configured with rounded adjoining edges to provide a substantially rectangular radial cross section with rounded corners.

With particular reference to Figure 2, the cylindrical section 14 of can 10 provides for an enlarged opening that leads into the interior of prismatic section 12. Cylindrical section 14 provides the big mouth round opening 18 having a diameter  $D_1$  that is greater than the cross-sectional width  $W_1$  between opposite walls of the prismatic section 12. Moreover, it is preferred that the big mouth diameter  $D_1$  of cylindrical section 14 be equal to or greater than the largest cross-sectional width  $W_2$  of the interior of prismatic section 12 so that cell materials can be easily assembled into steel can 10 and will not be impeded by the configuration of cylindrical section 14.

The steel can 10 may be configured according to another embodiment as shown in Figure 3. According to this other embodiment, steel can 10 further includes the addition of flat tapered transitions 20 that transition at a sloped angle  $\theta$  from each of the planar side walls of prismatic section 12 to the cylindrical section 14. Each of the tapered transitions 20 is provided at a sloped angle  $\theta$  greater than zero degrees and up to ninety degrees. The tapered transition 20 provides a lead in for closing to aide in a smooth reduction in size of the cylindrical section 14. In addition, tapered transition 20 allows for enhanced handling and use in roller feeders and other assembly equipment present in the cell production assembly.

The prismatic steel can 10 with enlarged big mouth opening 18 is employed in accordance with a method of assembling an electrochemical cell according to the present invention. Referring to Figure 4, the cell assembly method 24 is illustrated therein. The cell assembly method 24 begins with the step 26 of forming a prismatic steel can 10 having a big mouth open end 18 as described above in connection with Figures 1-3. Steel can 10 can be formed with the prismatic section 12 and the cylindrical section 14 by deep drawing can formation techniques, stamping, hydroforming, or other various steel can manufacturing

techniques. The method of assembly of the present invention generally requires that the steel can 10 have a prismatic section 12 that is non-cylindrical and an enlarged big mouth round opening 18 having a diameter  $D_1$  that is equal to or greater than the maximum inside cross-sectional width  $W_2$  of the prismatic section 12 to allow for easy assembly of the cell's  
5 internal materials. This is particularly useful for allowing ring moulded cathode insertion techniques, in which the positive electrode, referred to as the cathode, is dispensed in the can in a preformed ring configuration.

For a ring moulded cathode cell assembly, cell assembly method 24 provides the step  
10 28 of forming one or more ring moulded cathodes. The process of forming ring moulded cathodes generally includes adding a measured charge of cathode mix to a ring shaped die set and, with the use of a die press, moulding the cathode mix into the shape of a ring. The process of forming ring moulded cathodes is widely known in the art. However, the  
15 moulded cathode rings of the present invention are preferably configured to substantially conform to the shape and size of the inside of the prismatic section 12, and have a cylindrical cavity extending centrally therethrough.

Next, step 30 provides for the insertion of one or more ring moulded cathodes into the steel can 10. This may be accomplished by loading a fixed number of one or more  
20 cathode rings onto a mandrel, which is then lowered into the can 10 and the cathode rings are pressed into the can by way of an upper punch. The number of cathode rings inserted into a particular cell may vary depending on the size of the cell. For cells having a length and width comparable to AAA and AAAA size alkaline cells, three or four cathode moulded  
25 rings may be adequate to form the cathode for each cell.

Referring briefly to Figure 5, the step 30 of inserting ring moulded cathodes into the can 10 is illustrated therein. Each of the moulded cathode rings 40 has a rectangular configuration that substantially conforms to the size and shape as defined by the interior walls of the prismatic section 12. The cathode rings 40 are inserted and stacked one on top  
30 of the other within the prismatic section 12, preferably in a snug-fit relationship such that each of the cathode rings abuts each of the surrounding walls on the inside of can 10. The outer walls defining the perimeter of each of the cathode rings may further be impregnated with carbon. In addition, each of the cathode rings includes a cylindrical opening 42

extending therethrough. When assembled in the can 10, the cylindrical openings 42 align to define the anode cavity into which the separator and anode are disposed.

Returning to the assembly method 24 of Figure 4, subsequent to insertion of the ring  
5 moulded cathode into the prismatic section of can 10, an inner cylindrical cavity extends through the central longitudinal axis of can 10 and the cathode substantially consumes the remaining volume of the prismatic section 12. According to step 34, a cup-shaped separator is disposed within the inner cylindrical cavity. Disposed inside the cup-shaped separator is the negative electrode, referred to as the anode, which may include a gelled anode. An  
10 electrolyte solution is further disposed within can 10.

Once the above-identified cell materials have been disposed within can 10, cell assembly method 24 provides the step 36 of reducing the size of the big mouth open end 18 by reducing the size of cylindrical section 14. The partially assembled can 10 with reduced  
15 size round open end is shown in Figures 6 and 7 following assembly step 36, but prior to full assembly. The big mouth open end 18 is preferably reduced in size to a round open end 55 having a diameter  $D_2$  that is less than or equal to the minimum cross-sectional width  $W_1$  of the prismatic section 12 of can 10. The reduced size open end 55 is achieved by squeezing the cylindrical section 14 radially inward. This preferably forms a bottleneck 54 that  
20 transitions from the prismatic section 12 to the reduced size round open end 55.

It is preferred that the big mouth open end reduction not exceed a maximum diameter reduction of thirty percent (30%) by diameter (linear) reduction or seventy percent (70%) by cross-sectional area. In addition, the reduced round top end may include a substantially  
25 cylindrical section leading to a round open end. The cylindrical section is preferably short in length and the round cover sealingly engages to the open round end.

The reduction of big mouth opening 18 of diameter  $D_1$  to reduced size open end 55 of diameter  $D_2$  may be achieved by any one of a number of can closure techniques which  
30 include but are not limited to impact closing, beaded closing, rotary swaging, and roller closing. One such technique for closing the opening on an electrochemical cell is disclosed in US-A-3,069,489, entitled "Container Closure".

Referring again to Figure 4, assembly method 24 further includes step 38 in which a collector is assembled in contact with the anode, and a seal and cover assembly is assembled to the reduced size round open top end 55. This step 38 closes and seals the can 10.

Accordingly, the use of a can containing a big mouth open end 18 allows for easy insertion of cell materials, and by reducing the open end in size to a reduced size round open end allows for a round cover and seal assembly of the conventional type to close and seal the can. Reduction of the open end advantageously enables a plurality of cells to interface with each other without interference.

10 According to another embodiment, the assembly method 24 of the electrochemical cell may further include the step 32 of partially reducing the round big mouth open end, following the step 30 of inserting the ring moulded cathodes into the can. This intermediate reduction step 32 provides a partially reduced round open end, through which the separator, anode, and electrolyte are subsequently inserted pursuant to step 34. According to this  
15 approach, step 36 completes the reduction in the size of the round open end to its fully reduced dimension, and the seal and cover assembly is then assembled thereto.

Referring to Figures 8 and 9, a fully assembled electrochemical cell 50 assembled according to assembly method 24 of the present invention is shown therein. The active cell  
20 materials are shown disposed substantially within the prismatic section 12 of can 10. A round cover and seal assembly 56 is assembled to the reduced size open end of can 10. With adequate reduction in size of the open end, the round cover and seal assembly 56 is equal to or less than the cross-sectional width  $W_1$  of the prismatic section 12. Accordingly, the round cover and seal assembly 56 preferably does not extend radially beyond any of the side walls  
25 defining the prismatic section 12. The round cover and seal assembly 56 can be easily welded, attached by adhesive or otherwise assembled to the reduced size round top end.

The cover and seal assembly 56 with outer negative cover 62 is shown assembled to the top end of the cell 50. A thin layer of shrink tube insulation 72 covers the sides of steel  
30 can 10 to electrically insulate the metal casing of the cell. The cathode 40, preferably formed of a mixture of manganese dioxide, graphite, potassium hydroxide solution, deionised water, and other additives, is disposed between the separator 44 and inner walls of can 10 substantially throughout the prismatic section 12. The cup-shaped separator 44 is preferably

formed of a non-woven fabric that prevents migration of any solid particles in the cell. As shown, the active materials of cell 50, including the anode 46 and cathode 40, are substantially disposed within the prismatic section 12.

5           Cover and seal assembly 56 provides the closure to the assembly of cell 50 and includes a seal body 76 and compression member 74. The seal body 76 is generally shaped like a disk and made from electrically non-conductive material. The compression member 74 is a tubular-shaped metallic component that compresses the seal body 76 around the current collector 70. The seal assembly 56 also includes an outer negative cover 62 welded  
10 to the exposed end of the current collector 70 to form the cell's negative terminal. The rim of steel can 10 is crimped inwardly toward the cell body to form a seal. The seal assembly 56 with cover 62 may include a conventional round assembly, such as that disclosed in US-A-5,422,201.

15           The bottom end 16 of cell 50 serves as a positive cover to provide a positive cell terminal. The cover and seal assembly 56 includes a negative cell cover terminal 62. When using a prismatic can 10, cell 50 realises an increased volume in the prismatic section 12 in contrast to the conventional cylindrical cell of a diameter equal to cell wall width  $W_1$ , while  
20 having a round top end 55 that easily accommodates a standard round negative cover and seal assembly 56. This allows for an increase in active cell materials over that of the conventional cylindrical cell of a size having a diameter equal to the width of the side walls of the prismatic section 12.

25           It should be appreciated that the negative electrode, referred to as the anode 46, is preferably disposed in the inner cylindrical volume of the prismatic section 12 of can 10, while the positive electrode, referred to as the cathode 40, fills the volume between the separator 44 and the interior walls of the steel can 10, including all the corners of the can 10. By providing a rectangular configuration, the volume within the prismatic section 12 of cell  
30 50 is larger than that of a conventional cylindrical cell having dimensions that would fit within the rectangular walls of cell 50. This allows for an increase in the volume of the cathode 40 as well as the anode 46. In addition, the cup-shaped separator 44 may be further disposed radially outwardly from the longitudinal axis of cell 50 so as to provide a greater anode-to-cathode interface surface areas separating the anode 46 and cathode 40 from each

other. It should be appreciated that the additional active materials, including those disposed in the corners of the cathode 40, discharge to increase the capacity of the cell 50.

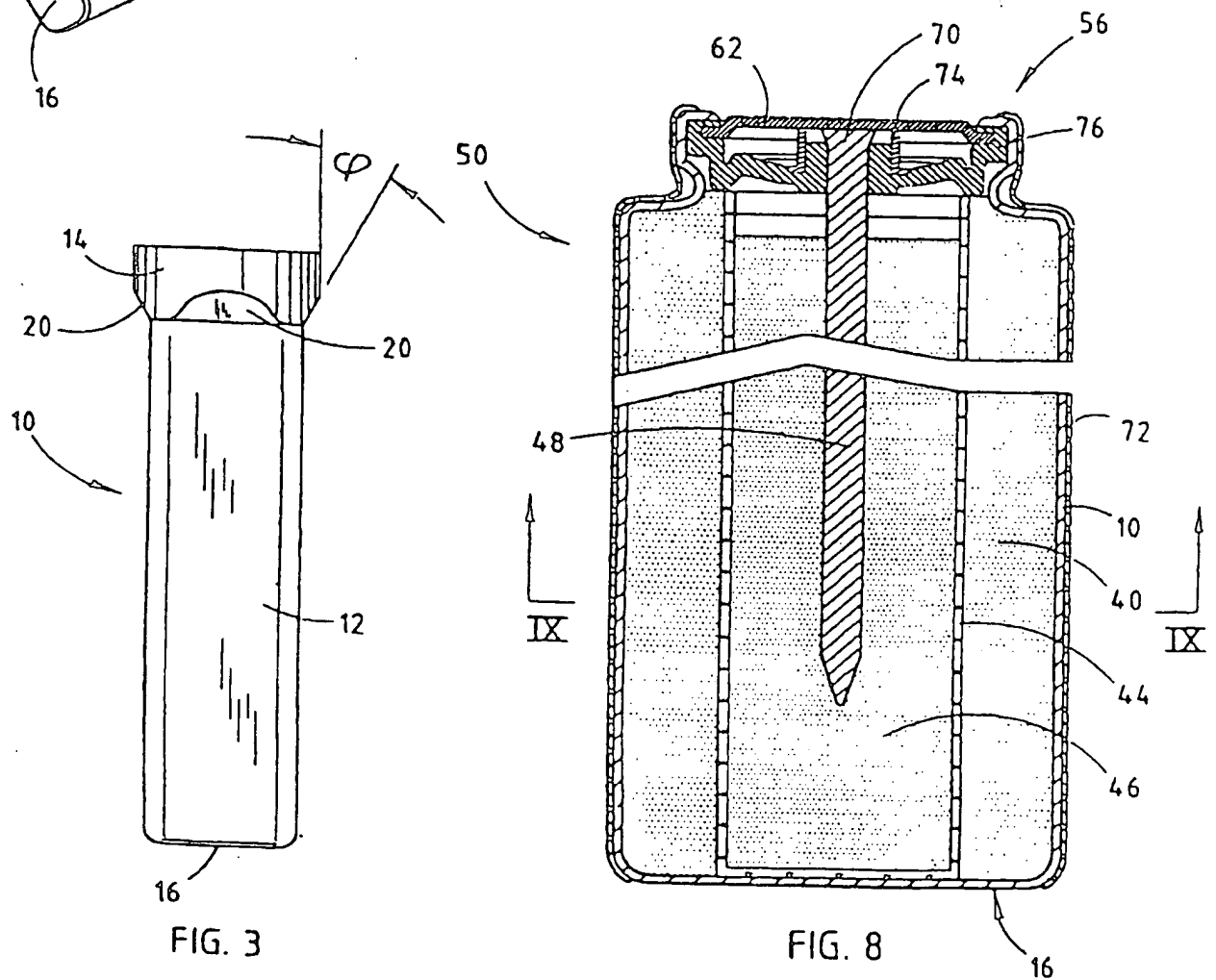
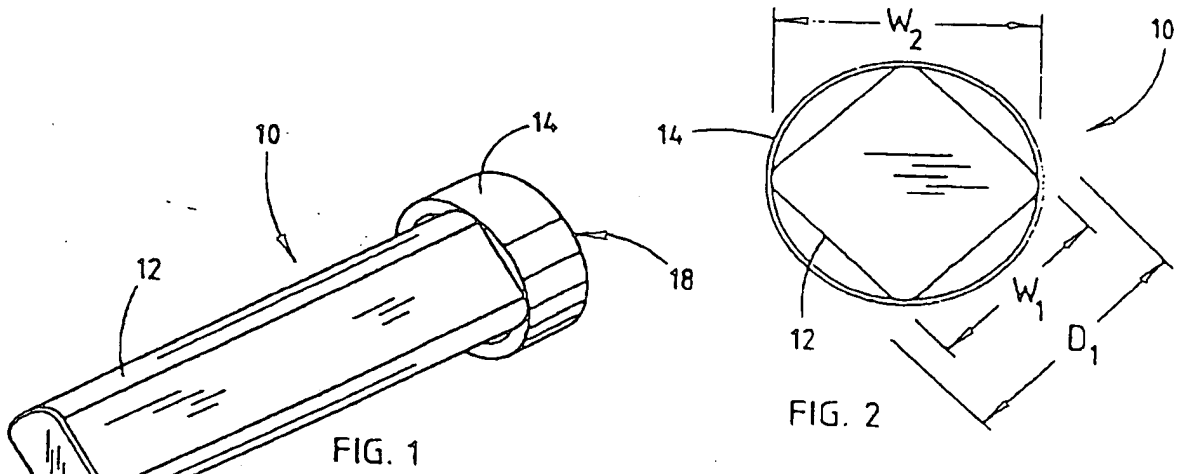
Cell 50 of the present invention advantageously employs a can 10 having a non-cylindrical prismatic section 12 with a large big mouth opening 18 at one end for receiving active materials of the cell, and is particularly well suited for a ring moulded cathode assembly. However, it should be appreciated that the assembly method of the present invention is likewise applicable to other cathodic assembly techniques such as impact moulding. In addition, the teachings of the present invention are not limited to bobbin type cells, as such teachings may be applicable to other cell assemblies such as the jelly roll configuration or stacked plate cell assemblies, among other possible cell assemblies.

Claims:

1. A method of assembling an electrochemical cell, comprising using an open-ended, non-cylindrical can, the mouth of the open end being generally circular, the mouth having no dimension smaller than any dimension of the radial cross-section of the can, and wherein the mouth of the can is reduced in size during or after the loading of the other elements, before being sealed with an end cover.
2. A method of assembling an electrochemical cell comprising the steps of:
  - providing a can having a prismatic section with a closed bottom end and a big mouth open top end that is substantially round with a diameter equal to or greater than the maximum inside cross-sectional width of the prismatic section;
  - disposing a cathode through the big mouth open top end and into the prismatic section, the cathode having a cavity centrally formed therein and disposed so that the cathode consumes a substantial volume of the prismatic section between the cavity and inner walls of the can;
  - disposing a separator within the cavity;
  - disposing an anode within the separator in the cavity;
  - reducing the size of the big mouth open top end of the can to provide a reduced size round open top end; and
  - assembling a cover to the reduced size round open top end.
3. A cell according to claim 1 or 2, wherein the body of the can has a substantially fixed cross-section along its length.
4. A cell according to any preceding claim, wherein the mouth is coaxial with the remainder of the body of the can.
5. A cell according to any preceding claim, wherein the mouth of the can, immediately prior to sealing, has no dimension exceeding the greatest of any of those of the radial cross-section of the can.

6. A cell according to any preceding claim, wherein the reduced mouth is substantially circular.
7. A method according to any preceding claim, further comprising the step of forming the can to include a cylindrical section that provides the mouth.
8. A method according to any preceding claim, further comprising the step of forming a tapered transition from the body of the can to the mouth.
9. A method according to any preceding claim, wherein the step of reducing the mouth includes the step of rotary swaging.
10. A method according to any preceding claim, wherein the can has a substantially rectangular section.
11. A method according to any preceding claim, wherein a cathode is disposed into the can by a cathode ring moulding process.
12. A method according to claim 11, wherein the cathode ring moulding process comprises inserting multiple cathode rings stacked one on top of another.
13. A method according to any preceding claim, further comprising the step of dispensing a current collector in contact with the anode.
14. A method according to any preceding claim, wherein the can is a steel can.
15. A cell prepared by a method according to any preceding claim.
16. An electrochemical cell comprising a can which has had an oversize mouth, of dimensions greater than those of the remainder of the radial cross-section of the can, reduced to a size less than any maximum radial dimension of the can.





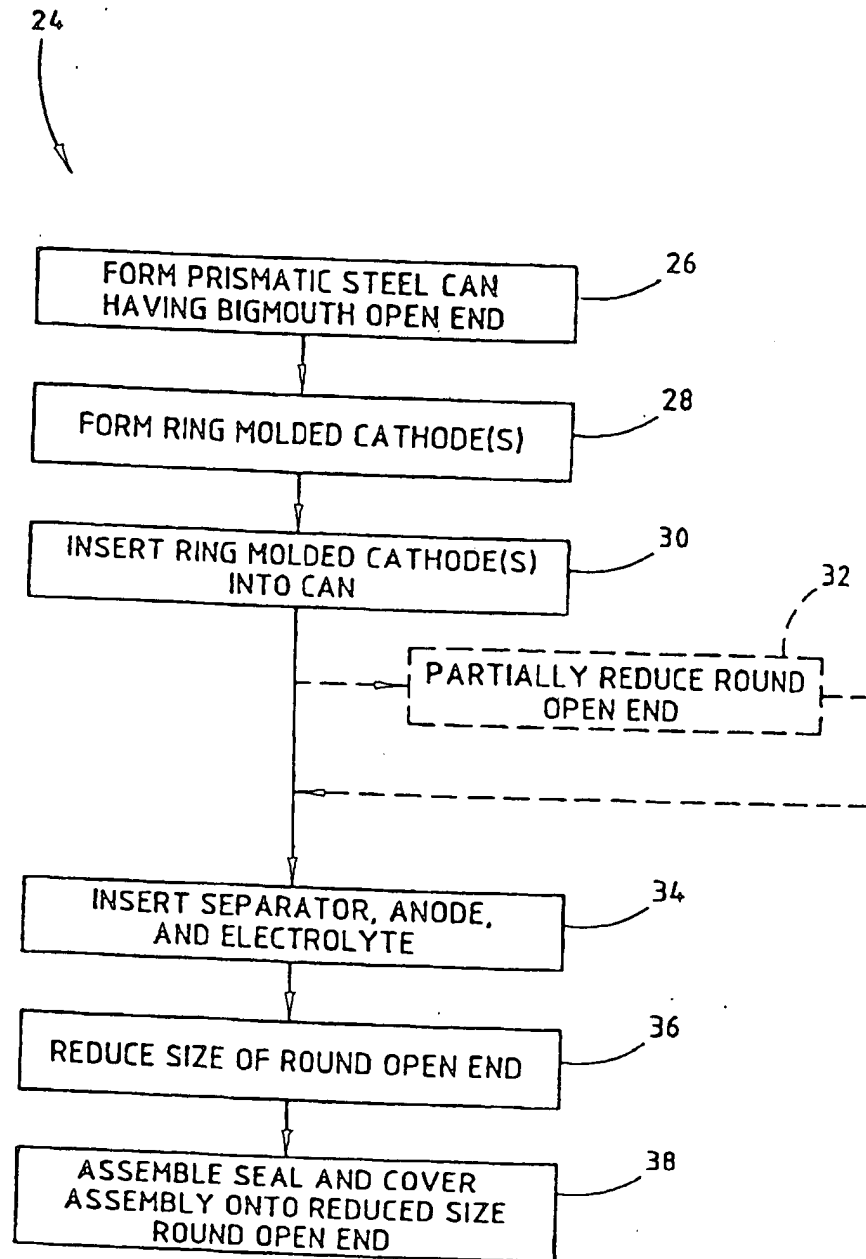


FIG. 4

